

Gift to the California Institute of Mining Engineers
J. C. Branner

THE MANGANESE DEPOSITS

OF

Bahia and Minas, Brazil.

BY

PROF. JOHN C. BRANNER,
STANFORD UNIVERSITY,
CALIFORNIA.

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The Manganese-Deposits of Bahia and Minas, Brazil.

BY PROF. JOHN C. BRANNER, STANFORD UNIVERSITY, CALIFORNIA.

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WITHIN a couple of years I have received many inquiries in regard to the manganese-mines of Brazil. These inquiries were doubtless directed to me because I had lived and travelled in Brazil for more than eight years, and was therefore supposed to be pretty well acquainted with its geology and mineral resources. Somewhat to my chagrin, I not only knew nothing of manganese-mines in that country, but I had never before heard of the mineral having been found here in quantity, and I did not even know in what State the mines were located.

The present summer found me in Brazil again, trying to finish up some of my early geological investigations along the northeast coast, and I have used the occasion to find out something about the manganese-deposits.

Very little is known of these mines, even in Brazil. While at Pernambuco I was told that they were in the distant interior of the State of Bahia. In August I reached Bahia, and there I found out, concerning the mines and their geology, enough to be worth telling for the benefit of those interested in the mining or using of this mineral.

Thus far, all the manganese-ore shipped from this State has come from two mines, the principal one of which is known as the Pedras Pretas mine. This was the first mine opened, is the best developed, and was the original discovery; the second one is on an adjoining tract, and the general geology and natural conditions are about the same in both.

The Pedras Pretas mine is on the Nazareth-Amargosa railway, twenty-six kilometers west of the town of Nazareth, which is on tide-water, at the head of navigation, and is reached from the city of Bahia by a small side-wheel steamer that runs across the bay of Bahia and up the Rio Jaguaripe

to that place two or three times a week. The trip usually takes about six hours. The Amargosa railway, running out of Nazareth, passes within half a mile of the mines.

To my regret, though I started to visit these mines, I did not get further than Nazareth. There I met the gentlemen in charge of them; and, owing to necessary connections to be made with a long-period steamer down the coast, I was compelled to gather what information I could, and to turn back. What I have to say here, therefore, regarding the mines themselves, was obtained in conversation with Mr. Charles Nack, the chief owner of the Pedras Pretas property, and from the engineer's maps, sections, etc. For what I say of the general geology, I alone am responsible.

The geology of the deposit is of special interest; for, so far as I now recall, manganese has not before been found in such rocks, though there was, of course, no reason for supposing it might not be expected in them. These rocks are *decomposed crystalline schists*. Mr. Nack speaks of them as decomposed gneiss, and the rocks do have a certain resemblance to gneiss. Indeed, in many places through this part of the country, it is often difficult to say just where the gneisses end and the crystalline schists begin. The schist-series is exposed at the city of Bahia, and is common in all the eastern states of Brazil, along the inland margin of the Cretaceous belt that follows the coast from Rio Grande do Norte down nearly to Rio de Janeiro. These schists, and also the gneisses and granites that often accompany them, are in some places exposed as hard rocks, while in others they are profoundly decomposed. The railways in the States of Pernambuco, Parahyba do Norte and Alagôas have many deep cuts through granites, gneisses and crystalline schists completely decomposed in place. Some of these cuts are twenty meters and more in depth, with not a rock in them hard enough to require blasting.*

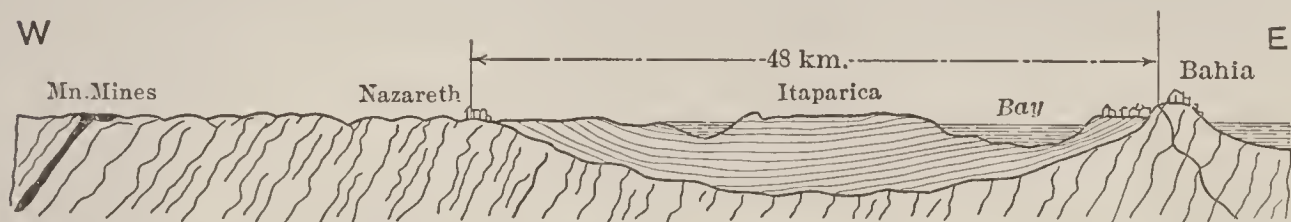
It is a peculiarity of these rocks, however, that while they are often decomposed to a depth of a hundred meters or more, there is no telling where one will come abruptly to the end of this decomposition. Here and there, throughout these regions of rock-decay, are bare peaks of solid granite, gneiss or schist,

* See "The Decomposition of Rocks in Brazil," by J. C. Branner, *Bull. Geol. Soc. Amer.*, vii., 255-314.

hundreds of meters in height. In the railway-cuts one may often see half of the cut in solid rock and the other half in clays that have been excavated with pick and shovel alone.

To come to the geology of the particular region with which we are here concerned:—the city of Bahia stands upon crystalline schists cut by eruptive dikes. Immediately west of the city is a Cretaceous basin that rests unconformably upon these crystalline rocks, and extends westward to within a couple of kilometers of the town of Nazareth—a distance, as the parrot flies, of about forty-eight kilometers. At Nazareth the schists are so decomposed that solid rocks in place are to be seen only in the stream-beds, and here and there in the hills. It is in these decomposed rocks that the manganese is found at the Pedras Pretas mine, lying, according to Mr. Nack, twenty-six kilometers further west. Fig. 1 is an ideal section, from Bahia westward.

FIG. 1.

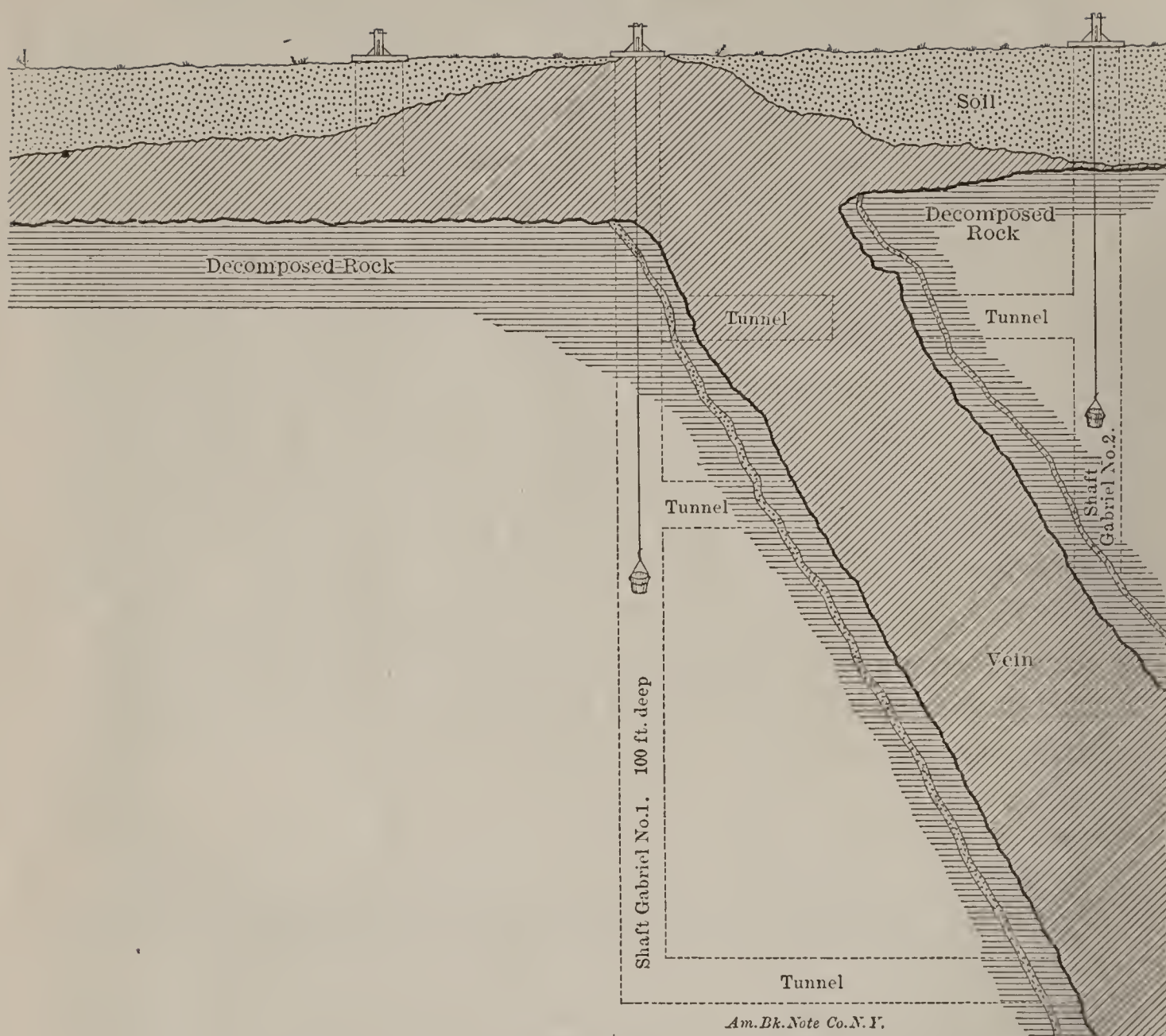


Ideal Section from Bahia to the Pedras Pretas Manganese-Mines. The underlying rocks are crystalline schists, with eruptive dikes, and possibly some granites and gneisses. The beds resting upon these are Cretaceous sediments.

Nothing definite is known with regard to the geologic age of these rocks; and the only opinion safe to venture is that they are very old. In the State of Sergipe, next north of Bahia, a series of rocks, *believed* to be Paleozoic, rests unconformably upon gneisses and schists. This would make the latter older than the Carboniferous at least. Some years ago Professor O. A. Derby, if I remember correctly (for this is written away from my Brazilian library), published in the *American Journal of Science* an article showing that some of these crystalline rocks were to be correlated with the Laurentian rocks of Canada, basing this view upon the discovery of what was thought by Sir William Dawson to be *Eozoon canadense*.* Leaving aside the question about *Eozoon*, I can only say that, so far as general resemblance over large rock-areas can be trusted for such correlation, I am altogether disposed to agree with Professor

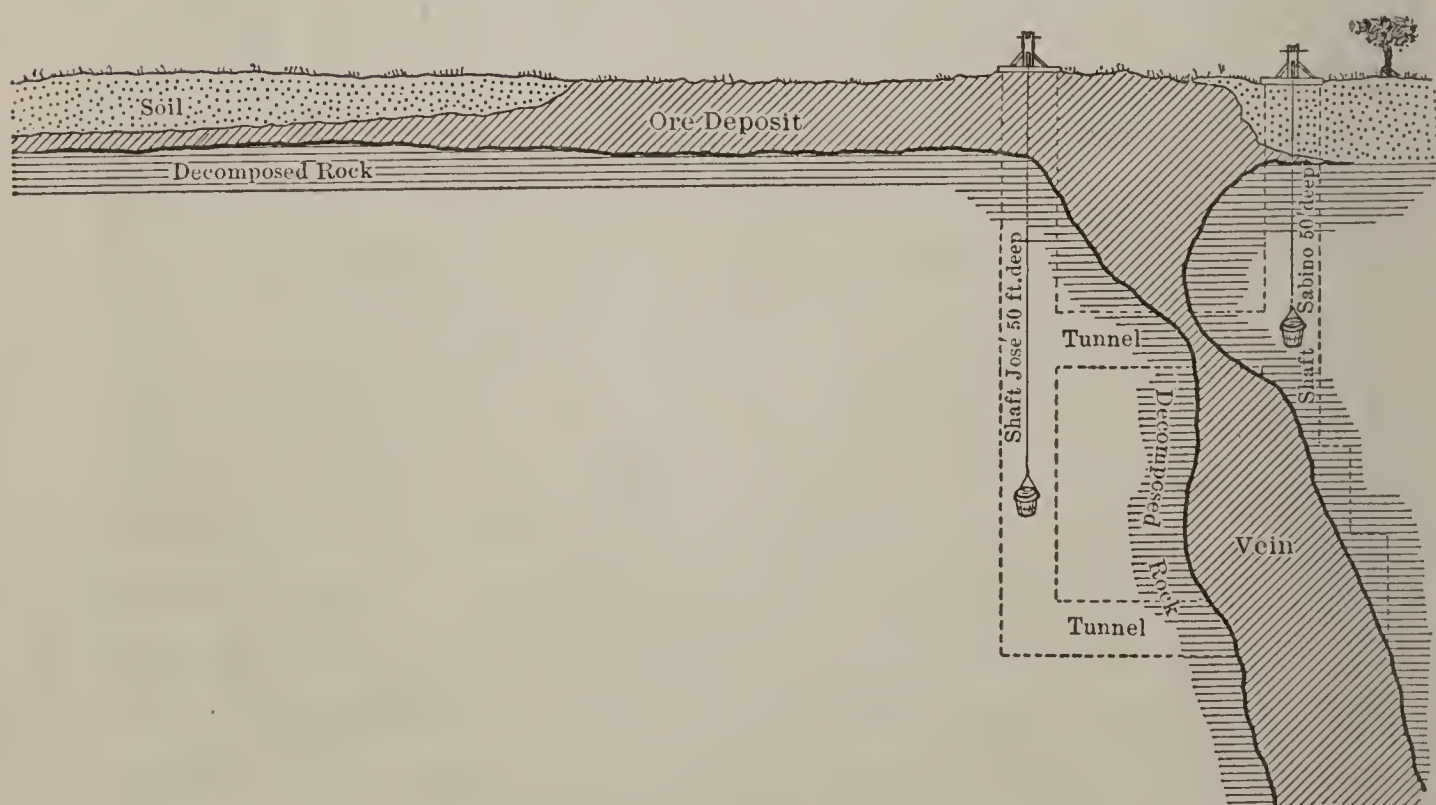
* *Am. Jour. Sci.*, cxix., 326.

FIG. 2.



Section through the Pedras Pretas Manganese-Mines, Bahia, Brazil.
Scale, 1 inch = 25 feet.

FIG. 3.



Section through the Ore-Body and Workings of the Pedras Pretas Mine, Bahia, Brazil.
Scale, 1 inch = 25 feet, nearly.

FIG. 4.



Open Cut in Surface Clay (Decomposed Rock), Pedras Pretas Manganese-Mine, Bahia, Brazil.

FIG. 5.



Method of Cleaning Manganese-Ore at the Pedras Pretas Mines. The ore is dried by fire upon a grate of railway-iron, shown on the right; the clay is then knocked off by women, and the ore is dropped into the ore-shoots on the left.

Derby. I dare say Professor Van Hise would be struck by the strong resemblance between these Brazilian schists and those of the Algonkian of Wisconsin, Minnesota, etc. And it is interesting to remember that these Brazilian manganese-beds are thus in rocks of approximately the same geologic age, and certainly of the same general appearance and characteristics, as the great iron-bearing series of the northwestern United States.

The country in which the manganese-mines are located is the comparatively low, hilly coastal region of eastern Brazil. The elevation of the water-shed at the mines is 198 meters above tide-level, and 70 meters above the track of the Amargosa railway, near by. This belt of country is covered by dense forests. The property of the Pedras Pretas Company consists of 295 acres of land, lying between Nago and Mutum creeks, and sloping northward towards the former stream. The other mine now being opened lies just south of the Pedras Pretas property, on the south-facing slope of the same hill.

The ore is psilomelane, and, in so far as one can judge by looking at it, fine ore it is. Hundreds of tons of it were piled on the wharf at Nazareth when I was there, on the 24th and 25th of August, 1899. Compared with the Arkansas and Georgia ores, it appeared to me to be unusually clean, though all of it is somewhat stained with red clay. Some of the lumps are botryoidal in form, but most of them are angular, and many are more than two feet in diameter. I am told that at the mines it is no uncommon thing to find lumps that weigh one and a half tons. The smallest pieces on the ore-piles I saw are larger than one's fist; and these pieces make but a small part of the ore on the heaps.

The Pedras Pretas mine is in soft earth, save where large masses of solid ore have been drifted into. Most of the ore thus far shipped has come from the great horizontal sheet that spreads out, almost or quite on the surface of the ground.

From the engineer's maps and sections (Figs. 2 and 3) one can see just how much is fact, and how much theory, with regard to the size and shape of the ore-body. It seems evident that there is a sheet, bed, or vein, as one may choose to call it, of ore, standing at an angle of sixty degrees, and varying in thickness from a few decimeters to ten meters. The great surface-deposits I take to be the accumulation from the breaking-up

and weathering-out of the bed, and the removal of the clays about it*—just as the Arkansas ores come from the decomposition of limestones. Most of the ore thus far shipped has come from these surface-accumulations. Fig. 4, from a photograph said to have been taken in June last, shows one of the open cuts in this surface-clay.

Anyone acquainted with the manganese-mines of Arkansas, Georgia and Virginia, will be struck by the general similarity of the conditions under which the ores occur in Brazil. The only remarkable difference is in the age of the rocks—the Brazilian ones being probably much older.

Fig. 5 shows a method of ore-cleaning that may be useful elsewhere. On the right is a pit covered with railway-iron, the rails lying close against each other, and sloping gently towards the shed. A fire is kept beneath these rails, and all the ore that comes from the pits covered with clay is dumped upon these hot bars, and left there until the clay dries. It is then raked off, and the clay is removed by rapping the ore-lumps with hammers. The ore is then dropped on the chutes shown on the left. This ore-cleaning is all done by women. When the ore comes from the mines clean, the cars are dumped immediately into the chutes.

The company owns a tramway over which its ore is hauled to the Nazareth-Amargosa railway, by which it is taken to the wharf at Nazareth. At this place it is loaded on small sailing-vessels and sent to Itaparica, a small town on the Bay of Bahia, where it is put on board sailing-vessels for Europe or the United States.

The government-charges here are quite reasonable—a little more than one milreis a ton on the exported ore. At the present rate of exchange, this is about fifteen cents of our American money. I am told that sailing-vessels charge ten shillings a ton to carry the ore from Bahia to Philadelphia.

As reported to me by the mine-owners, the total cost (to them) of this manganese, laid down in Philadelphia, is four dollars and ninety-five cents a ton. This includes the cost of mine management. From my own knowledge of this country, and

* I have often found these crystalline schists to have a pretty uniform dip and strike over large areas through eastern Brazil. In the interior of the State of Pernambuco I found that this uniformity was due to repeated parallel faults.

of the price and character of labor, I am disposed to think this a thoroughly conservative estimate.

The proximity of the fine sea-port and large city of Bahia makes it possible for those living at these mines to have many of the luxuries of life, while the many steamer-lines running to this port from Europe (and one from the United States) keep them from feeling that they are very far from the rest of the world. On the whole, the mines are more favorably located than any others with which I am acquainted in Brazil. Labor is very cheap, and, if properly treated, is fairly good. There are a large saw-mill and many shops at the town of Nazareth.

As for the prospects of finding other good manganese-deposits, it would be a mere waste of words to speak, save in the most general terms. The geology of the country is but imperfectly known at the best, and nothing at all is known of the precise distribution of the series of rocks in which these particular deposits are found. The federal government has no lands of its own. When the republic was established, it was provided in the Constitution that all federal lands should be turned over to the States in which the lands lay. There is, therefore, no incentive for the federal government to maintain a geological survey, since such a survey would be for the sole direct benefit of the individual states. The States themselves, with the exceptions of São Paulo and Minas Geraes, have never undertaken such work; and the Minas Geraes survey has already been stopped, before any geological work proper had been undertaken. I regret to say that there seems but little likelihood of the States undertaking surveys. If any one wants to know where the crystalline schists occur in the great State of Bahia, in order to know where to seek manganese, he need not search the State reports for such information; he can either gather the information directly in the field, or he can leave the matter alone. But such preliminary field-work is quite beyond the powers of private organizations. So he leaves it alone; and whatever new discoveries are made must be made by some happy chance.

POSTSCRIPT.

After the above was written (at Bahia, in August, 1899), I went to Rio de Janeiro, with the expectation of visiting the

manganese-mines near Ouro Preto, in the State of Minas Geraes. I found, however, that a competent English mining engineer had already spent some time studying them, and that his results were shortly to be published in England; and I therefore abandoned my plans. The Minas Geraes manganese-deposits are near the Miguel Burnier Station on the Ouro Preto branch of the Central railway (496 kilometers north of Rio), and at Queluz on the main line (463 kilometers from Rio). From what Professor Derby and others who have seen the mines tell me they are all open cuts in rocks decomposed in place. With the general geology of the region in which these mines are located I am already acquainted. It is very much like that of the Bahia manganese-mines.

Dr. Antonio Olyntho dos Santos Pires, Professor in the Escola de Minas at Ouro Preto, and one of the leading mining engineers of Brazil, has kindly furnished me the following information regarding the Minas manganese-deposits. His letter is dated October 22, 1899.

“About five years ago the manganese-mines of the State of Minas began to attract attention, though in many places these deposits were already well known. In the zone between Miguel Burnier and Itabira, on the Central do Brazil railway, two iron-furnaces had been started alongside of magnificent iron-deposits; but the difficulty of getting charcoal for fuel caused the directors of one of these furnaces to turn their attention to the manganese, and to attempt its exportation. The result of this attempt was favorable; and from this began the regular mining and shipping of this mineral.

“At present there are three companies engaged in this work, besides the small organizations that are formed and disappear from time to time. These companies operate in the zone between Lafayette and Burnier stations, along the branch railway running from Burnier to Ouro Preto, and lately in the vicinity of the last-named city. It is only within the last two years that these mining operations have become systematized. Of the geology of these deposits no careful studies have been made. The region is very mountainous, and has been much disturbed, and only a thorough and careful examination can warrant hypotheses—which, thus far, no one has ventured to formulate. The order of the beds, as shown in most of the cuts along the Ouro Preto branch of the railway, is about as follows:

1. Limestone.
2. Ferruginous quartzite or itabirite.
3. Clays.
4. Compact itabirite.
5. Manganese.
6. *Jacutinga*, or friable itabirite.
7. Clays.
8. Stratified crystalline rocks, with limonite and impure manganese oxides.
9. Clay-shales.
10. *Canga*, or ferruginous conglomerate.

“The kinds of manganese most frequently found are *manganite* ($\text{Mn}_2\text{O}_3, \text{H}_2\text{O}$) and *pyrolusite* (MnO_2), and less frequently the other oxides. The itabirite with which the manganese is generally interbedded is composed of hematite and layers of quartz. It is sometimes so compact that it is called ironstone; and again it is friable, when it is known as *jacutinga*.

“I give herewith analyses showing the percentage of metallic manganese, and of the principal impurities contained in the ore. These analyses are copied from the register of analyses of the School of Mines, where we examine all the ores presented.

“The exportation of manganese from the State of Minas began (by way of the port of Rio de Janeiro), upon a very small scale, in 1894. In subsequent years it was as follows:

EXPORTS OF MANGANESE FROM MINAS
(via Rio de Janeiro).

	Metric Tons.*
1895,	6,765
1896,	13,020
1897,	17,967
1898,	29,630
1899 (to Sept.),	60,107

“This exportation was through the Miguel Burnier station, at kilometer 498 on the Central do Brazil railway. There has also been some manganese exported from Lafayette station (kilometer 462) and from Ouro Preto (kilometer 540); but only during the present year has it become regular. To the figures given above there should therefore be added at least 15 or 20 per cent., to show the total exportation of manganese from the State of Minas.

“These figures show that mining operations are increasing; and the work planned and development now under way lead to the belief that the output for next year will be much larger than ever. Moreover, other districts, such as that of Sabará and Bello Horizonte, along the line of the Central railway, are proving to contain deposits of importance which must certainly be developed shortly.”

The following are the analyses of manganese-ore, made at the School of Mines at Ouro Preto, and kindly furnished by Dr. Antonio Olyntho.

I.

Sample from Kilometer 499, Central do Brazil Railway.

	Per cent.
Loss on ignition,	15.200
Insoluble in HCl,	1.560
Sesquioxide of iron, and alumina,	4.600
Oxide of manganese,	76.200
Baryta,	1.840
Phosphoric acid,	0.019
Total,	99.419
Metallic manganese,	54.96

* The metric ton is 2204 lbs. avoirdupois.

II.

Sample from Kilometer 500, Central do Brazil Railway.

	Per cent.
Loss on ignition,	14.750
Insoluble in HCl,	0.700
Sesquioxide of iron,	4.000
Alumina,	2.000
Lime and magnesia,	0.000
Oxide of manganese,	75.600
Phosphoric acid,	0.051
Baryta,	2.300
Total,	99.401
Metallic manganese,	50.46

III.

Sample from Kilometer 503, Central do Brazil Railway.

	Per cent.
Loss on ignition,	13.500
Insoluble in HCl,	1.000
Sesquioxide of iron and manganese,	5.700
Oxide of manganese,	70.000
Phosphoric acid,	0.032
Baryta,	8.800
Lime and magnesia,	trace
Total,	99.032
Metallic manganese,	50.44

IV.

Sample from Itabira, Kilometer 524, Central do Brazil Railway.

	Per cent.
Hygroscopic moisture,	1.15
Insoluble in HCl,	13.84
Metallic manganese,	31.75

V.

Sample from Vigia, Kilometer 500, between Burnier and Itabira Stations.

	Per cent.
Insoluble in HCl,	0.65
Metallic manganese,	55.40

VI.

Sample from Queluz, Lafayette Station, Kilometer 463, Central do Brazil Railway.

	I. Per cent.	II. Per cent.
Loss on ignition,	14.0	18.7
Insoluble in HCl,	52.0	5.0
Metallic manganese,	29.8	36.7

VII.

Sample from Rodrigo Silva, Kilometer 521, Central do Brazil Railway.

	I. Per cent.	II. Per cent.	III. Per cent.
Insoluble in HCl,	3.5	0.3	0.40
Metallic manganese,	60.1	62.0	60.90
Phosphorus,	0.154		

VIII.

Sample from Rodrigo Silva, another exposure.

	Per cent.
Insoluble in HCl,	1.65
Oxide of manganese,	69.00
Phosphoric acid,	0.160
Corresponding to	
Metallic manganese,	49.70
Phosphorus,	0.07

IX.

Sample from Hargreaves, Kilometer 515, Central do Brazil Railway.

	Per cent.
Insoluble in HCl,	1.8
Oxide of manganese,	71.5
Oxide of Iron and alumina,	14.6
Corresponding to	
Metallic manganese,	51.4

X.

Sample from Hargreaves, Capão Deposit.

	I. Per cent.	II. Per cent.
Insoluble in HCl,	0.4	0.3
Alumina,	12.5	
Metallic manganese,	48.96	57.4
Phosphoric acid,	0.096	

XI.

Sample from Saramenha, Kilometer 540.

	I. Per cent.
Loss on ignition,	18.50
Insoluble in HCl,	0.80
Alumina,	0.90
Sesquioxide of iron,	11.16
Oxide of manganese,	67.60
Baryta,	1.18
Phosphoric acid,	trace
Total,	100.14

XII.

Sample from Saramenha, another deposit.

	Per cent.
Insoluble in HCl,	0.60
Metallic manganese,	60.90

XIII.

Sample from Tres Cruzes, Kilometer 530.

	Per cent.
Insoluble in HCl,	1.50
Metallic manganese,	40.50

XIV.

Sample from Morro do Cruzeiro Ouro Preto, Kilometer 540.

	Per cent.
Insoluble in HCl,	0.7
Oxide of manganese,	65.0
Sesquioxide of iron and alumina,	20.0
Corresponding to	
Metallic manganese,	46.8

Dr. Olyntho continues :

“ The above-mentioned deposits are all upon the Ouro Preto branch of the Central do Brazil railway. Besides these there are others, not only along the line itself, but also at short distances from it. The Gandarella basin is one of the most interesting of this district.”

XV.

Sample from Gandarella, 20 km. from the Railway at Kilometer 551.

	Per cent.
Insoluble in HCl,	2.0
Metallic manganese,	50.7

In the vicinity of Bello Horizonte, the new capital of the State of Minas, 600 kilometers from Rio de Janeiro, beds of great thickness have been discovered.

XVI.

Samples from Acaba Mundo, S. E. of Bello Horizonte.

	I.	II.
	Per cent.	Per cent.
Insoluble in HCl,	6.5	1.00
Metallic manganese,	47.58	56.16

XVII.

Samples from Taguaral E. of Bello Horizonte.

	I.	II.
	Per cent.	Per cent.
Insoluble in HCl,	0.1	0.30
Metallic manganese,	60.09	60.08
Phosphorus,		0.022

XVIII.

Samples from Corumbá, State of Matto Grosso.

	I. Per cent.	II. Per cent.	III. Per cent.
Loss on ignition, . . .	9.85	9.50	8.85
Insoluble in HCl, . . .	1.86	0.65	0.60
Sesquioxide of iron and alumina,	14.40	13.50	12.50
Phosphoric acid, . . .	0.126	0.192	0.126
Metallic manganese, . .	47.52	50.80	51.50

In 1898 a monograph upon Brazilian manganese-ores, entitled *O Manganéz no Brazil*, by M. Ar-Rojado Ribeiro Lisboa, was published at Rio de Janeiro, pamphlet, 48 pp., and also, June 19, in the *Jornal do Commercio* of that city. This monograph gives analyses of the ore, together with the cost of mining and transportation, from twelve different localities. Being, unfortunately, unable at this time to quote these detailed statements, I substitute (what may be of greater value, as testimony from an entirely impartial source) a statement kindly furnished by Ledoux & Co., of New York City, who sample and assay the larger part of all shipments to the United States, giving the average of 40,000 tons of Brazil manganese-ore, as follows :

	Per cent.
Moisture,	7.60
Manganese,	54.08
Phosphorus,	0.03
Silica,	1.05
Iron,	0.90

In these shipments the different mines are not specified.

While I am speaking of mining in Brazil, I may use the occasion to answer certain questions often put to me by hopeful young miners, prospectors, metallurgists and mining engineers, with regard to the advisability of going to that country.

First and foremost, one should not go there at all unless he goes under a satisfactory contract. That is not the country for ventures.

Don't go into the Amazon valley for any considerable period—contract or no contract.

The language of the country is not Spanish, but Portuguese; and bad Spanish is not good Portuguese. One is utterly helpless there, unless he understands and speaks the language with

some sort of facility. French is of some use in three or four of the largest coast-cities, but up-country it is as useless as Choctaw.

The mining regions of Minas Geraes and the high interior generally are healthful for people of temperate habits. Beer-drinking is not temperance there. New-comers should not arrive in the months of February, March, April or May. In those months, yellow fever is generally at its worst.

